The magic of domain

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CPD 3DS

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Produced by UESTC - Software

Preface

Nice to meet you! We are iGEM（International Genetically Engineered Machine competition）UESTC-Software team——a group comprises curious undergraduate students. After six months of training, we still keep our love for synthetic biology, as well as to others outside the field of synthetic biology. To this end, we made this booklet to simply talk about “domain”——the main structure of our project this year.

Now you may be wondering what the domain is. You may be confused what’s the relationship between domain and protein. You may even have too much questions when it turns to the protein. But don’t worry, all these questions can be answered in this booklet! Now, let’s have a nice trip to the domain!

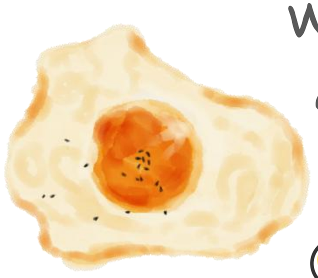
Catalogue

01

Exploring the origins of domains

01

Why are eggs easier to digest after frying?



Eggs are rich in protein. Proteins change in structure when heated, making them easier to digest and absorb.

02

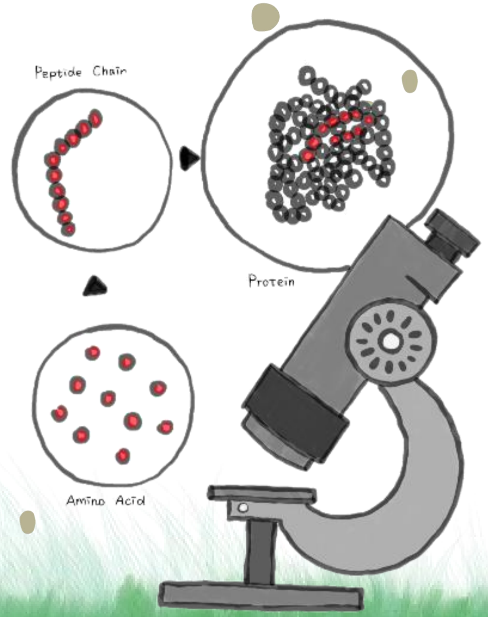
Why does pineapple taste sour and astringent?

Addition to being rich in vitamin C and sugar, pineapple pulp contains a lot of organic acids, as well as an enzyme called bromelain, which breaks down protein. This enzyme stimulates the lining of our mouth and the tender epidermis of our lips, giving us a tingling sensation if we don't soak in salt water first.

Many of the foods we eat are rich in protein:

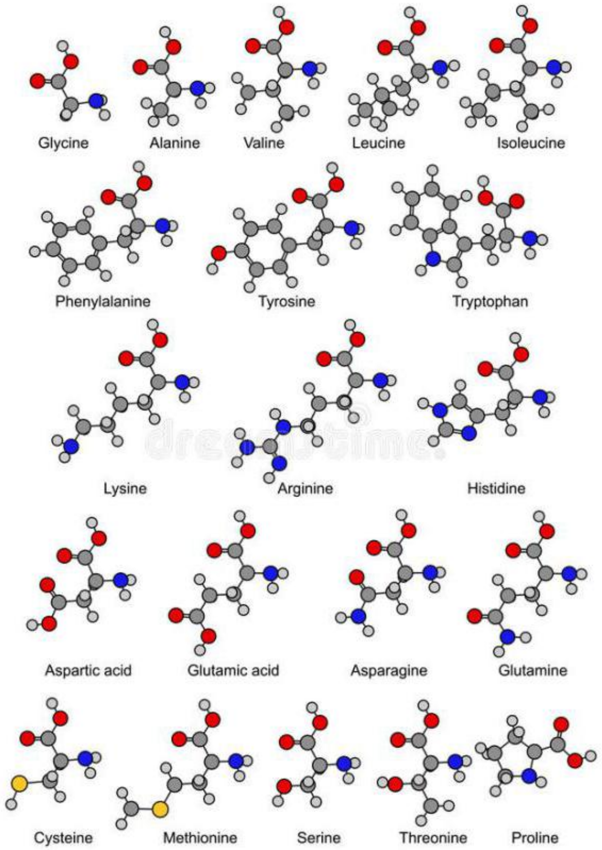
What is protein?

Proteins are made up of tiny elements -- amino acids.Here we think of them as tiny spheres connected by a biological reaction that forms a polypeptide chain.This is a chain structure drawn in the picture, and then a kind of material formed by coiled folding.

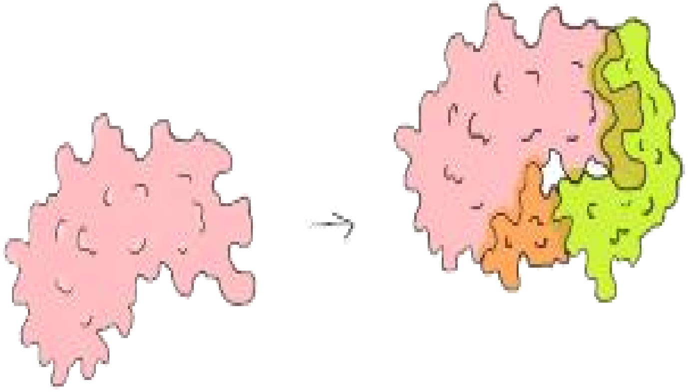


And the actual formula for amino acids, as shown on the right, is something made up of a few chemical elements.It's not as simple as we said.We need large amount of amino acids to make proteins.The process of analyzing proteins from amino acids is a very complex process.

So, can proteins be structured in other ways?



Just like a map of the world, if you build it from microscopic elements like water, earth and air, you need to. It would be much easier to combine the elements into continents and oceans, and then start from these parts to make a map.The microscopic elements of water, earth and air are like different amino acids, and the continents and oceans are our simplified protein domains.

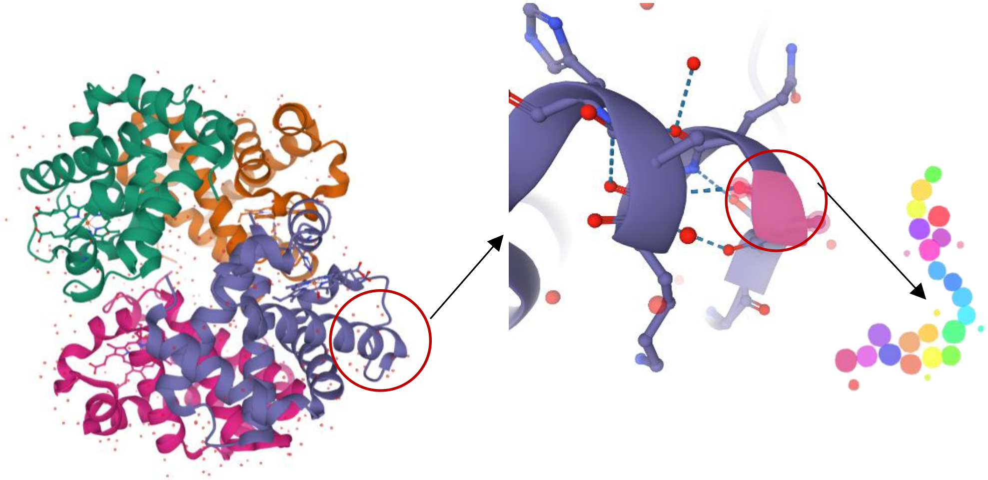


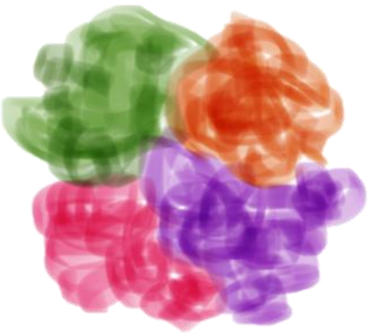
By further analyzing the structure of the proteins, and extracting and comparing their biological information, we came up with a completely new idea.Abandoning the cumbersome idea of starting from amino acids to build proteins, proteins are divided into several three-dimensional "structures", namely domains [1], according to their structural characteristics, and then splicing into a complete protein in the way of building blocks through these "structures".This is where the idea of blocks first came into being.

【 1 】 The Structural Domain is another level of structure that lies between a secondary and a tertiary structure.The so-called domain refers to the region of tightly spherical structure in the structure of protein subunits, also known as the domain.

Let's look at a concrete example.Why is our blood red? This is caused by the presence of hemoglobin in our blood, a special protein that transports oxygen inside red blood cells.That's the one on the left that looks like a jellybean.

So let's look at the structure of hemoglobin:





On the left, we can clearly see that the microstructure of hemoglobin can be divided into four domains.If you were to draw the amino acid structure of a small peptide chain, you would see the very complex colored beads on the right.Obviously, the domain division makes the structure of hemoglobin much simpler.

It's still hard to imagine building proteins out of domains in a plane, so can you make some domain building blocks and put them together in real life?So we came up with the idea of designing a set of protein domain building blocks -- Probrick.

02

Entering the world of domains

How many domains are there in the world?

There are 3 basic colors, 5 basic tastes, 20 common amino acids, 118 elements and about two million named species.

The number of domains is close to 400,000, but many of these domains are extremely similar. So, just like cookies in a store have one cabinet and chocolates have another cabinet, we divided similar domains into one category, 400,000 domains into 100 categories, and put the representatives of each category together to make

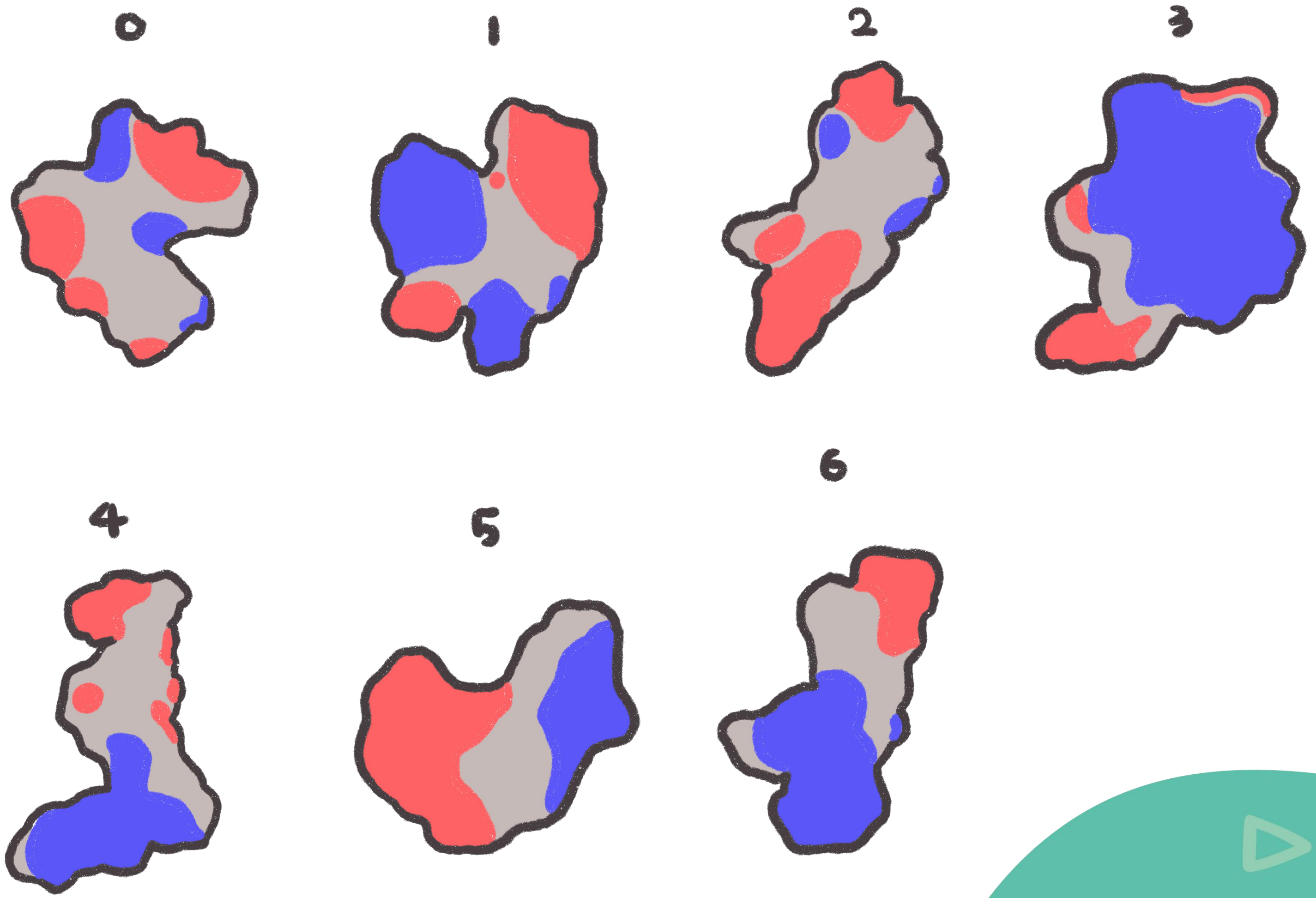
How are domains classified?

Perceptive, you may have spotted a problem: Where to put the chocolate chip cookies? Is it the chocolate cupboard or the cookie cupboard or a new cupboard?

Generally speaking, a chocolate cookie is a cookie with a large number of cookies and a small amount of chocolate, so it is more like a cookie and should be kept in the cookie cupboard！ The same is true of domains, domains that have the characteristics of both categories, and we put it in a more similar category.

The appearance of the probrick

Have you noticed what their shapes are like?



03

Building blocks class × work together

Acquaintance Probrick

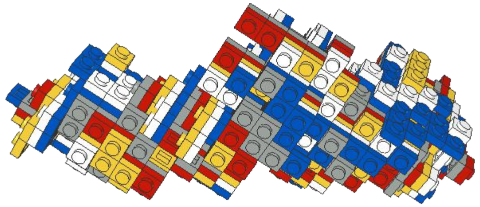
A protein can only be seen under an electron microscope, but a protein under the microscope does not give a direct picture of what a protein really looks like.

Have you ever imagined what protein looks like? Mom and dad and doctors often say "to eat more eggs, drink more milk to add protein", so, protein in the end is what it looks like? What are proteins made of? This question, perhaps even the parents themselves do not know, because the protein is smaller than the cell existence, the naked eye can not see. So, let's find out what proteins actually look like.

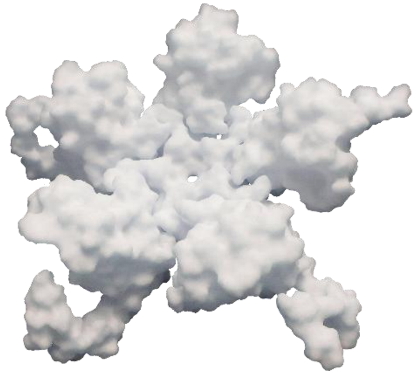
Probrick

To get a better idea of what the protein really looks like, the team at UESTC-Software built a set of Probrick bricks!

Flagellum motor protein model

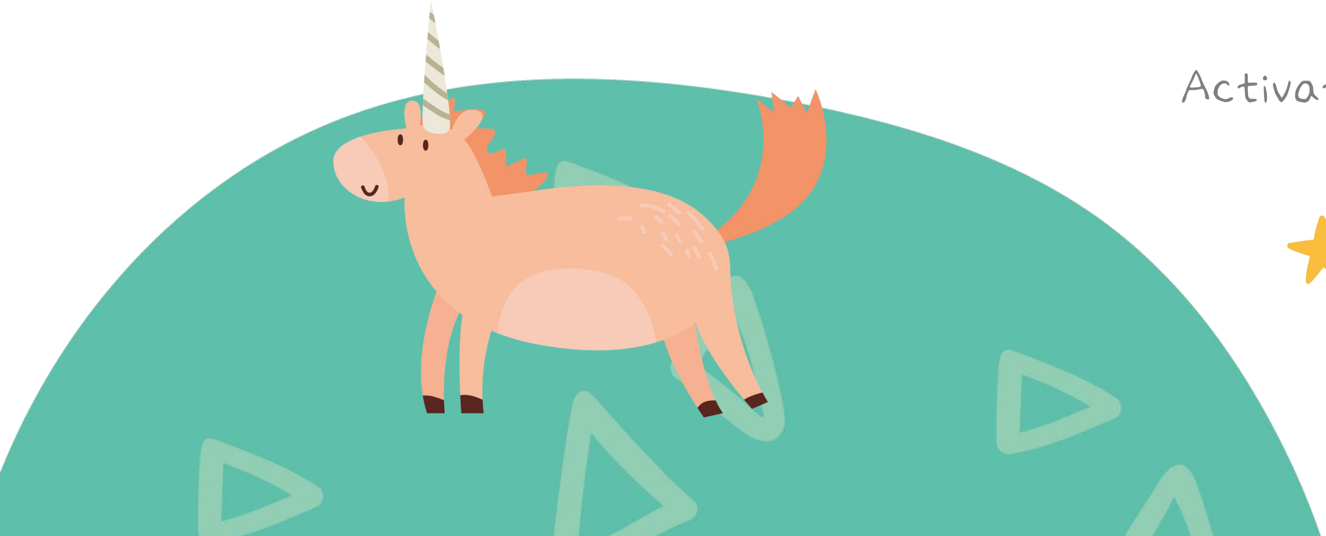


Flagellum motor protein block



Activate the enzyme protein model

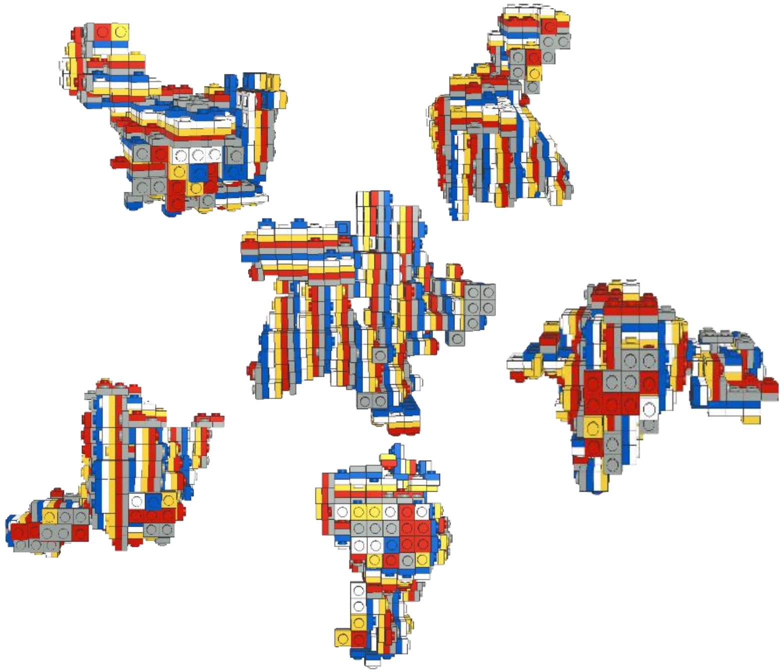
Activate the enzyme protein building block



The one on the left is a 3D printed model of a protein, and if you're careful, the one on the left is made up of six smaller pieces, and those smaller pieces are -- the 3D printed model of the domain.

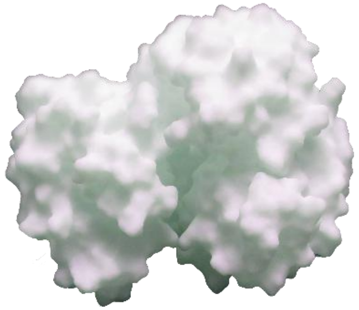
Let's do it

With so many shapely domains in sight, would you like to try your hand at how to assemble a protein?We developed a set of protein blocks like the one on the right, where you can use 100 domains probrick to make proteins, or to follow our instructions to make proteins, or to think creatively and splice them.Experience the fantastic ideas scientists have for building new proteins.Let's take a look at how to put them together.

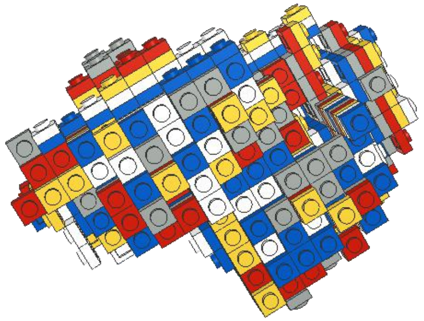


Activate the enzyme protein building block

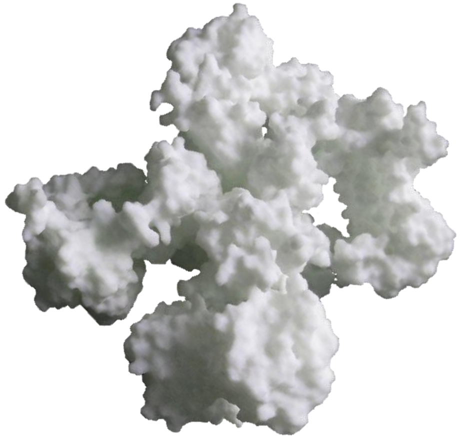
Let's do it



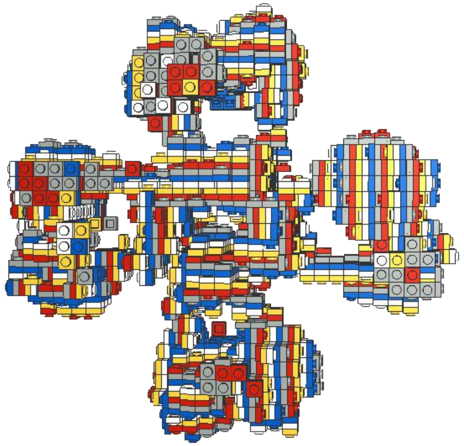
Hemoglobin model



Hemoglobin building block



The isomerase protein model



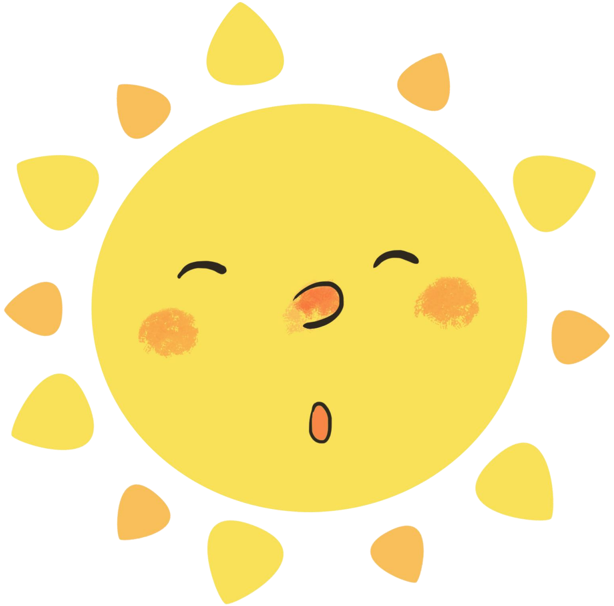
The isomerase protein block

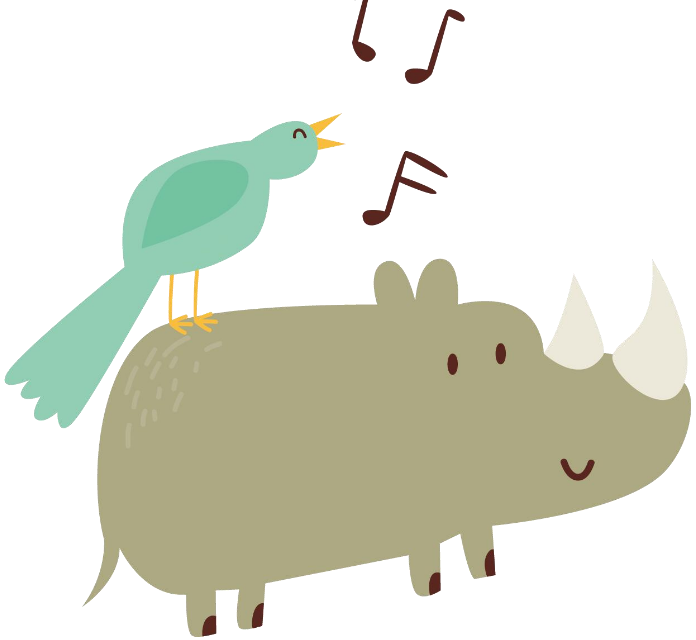
04

Domain design proteins

Scientists have reinvented proteins

Remember how many proteins there are in the world? Hundreds of thousands? Thousands? No, no one can say exactly how many kinds of proteins there are. In the authoritative Protein structure database, Protein Data Bank (PDB), more than 140,000 kinds of known proteins are included at present. Then, how do we get so much protein?





Nature has produced most of the known proteins -- natural proteins. But scientists are constantly exploring the unknown. They try to modify parts of natural proteins to make new ones. A more difficult modification would be to mimic natural proteins and make new, more powerful ones from scratch. Proteins synthesized through these pathways are called artificial proteins.

The scientific journey of the domain

Scientists who dare to think big always have brilliant and bold ideas, but in practice they run into all kinds of trouble.

As mentioned in the first lecture, the process of analyzing proteins from amino acids is a very complex process, just as the process of constructing artificial proteins from amino acids is also a very complex process. This process is similar to the familiar jigsaw puzzle. Imagine a giant map of the world. How long would it take to complete it from the smallest possible color block?

The scientific journey of the domain

Obviously, that's a lot of work, so scientists have come up with another way to reconstruct proteins through their domains, just as when we put together a map, we already have pieces of the continents and oceans, and putting them back together is a lot easier.It also provides a new way for the development of protein science to construct proteins through structural domains.

New proteins make the world more colorful

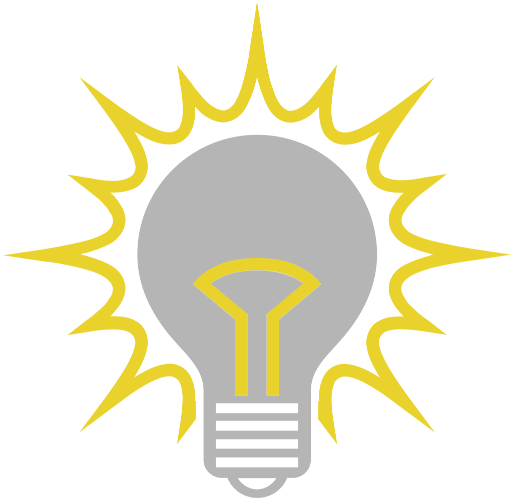
01

Protein has a variety of functions that give us the energy to explore the colorful world, and the lack of some proteins can cause a variety of health problems.

For example common "anaemia", be because the red blood cell in blood decreases be caused by, red blood cell decreases, the hemoglobin task force that carries oxygen in red blood cell "manpower is insufficient", the oxygen that the body gets is less, we may because of muscle hypoxia, respiratory center hypoxia, and become weak and weak, tired, sleepy;Without the immune protein, without enough protein guardians to protect our bodies, we are more likely to get sick.

02

In addition, there are many proteins in nature that are beneficial to human beings. They have many functions: to degrade pollutants, to break down garbage, to generate energy...However, humans are not using them in sufficient quantities or efficiently. As a result, we are still faced with a series of global environmental problems such as energy crises and cross-border movement of hazardous wastes.



Changing humans is the most feasible and convenient way to solve these problems, but can we do it by changing proteins? For example, if we know that some domains occur frequently in animal hemoglobin, which carries the most oxygen, then by replacing these domains with similar domains in human hemoglobin, it may be possible for human hemoglobin to have a stronger capacity to carry oxygen!

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That's the end of this lesson!

but

Your story with synthetic biology

Your story with iGEM

To be continued...

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